

task of bringing up the arrears of the annual bulletins of meteorological observations which began and ended with the bulletin for the year 1910, published in 1914 by the former *Directoria de Meteorologia e Astronomia*. Before beginning the publication of this extensive series it was thought best to prepare the collection of normals which has just appeared. He states that the publication should be regarded as provisional in character. The observations at Rio are lacking in homo-

geneity on account of various methods of exposure and observation, and in any case it is difficult to obtain representative data for that city on account of its extremely irregular topography. The observations at field stations were taken by comparatively untrained observers in most cases. Nevertheless this publication is a noteworthy contribution to the climatology of Brazil, furnishing a more comprehensive collection of normals than has heretofore appeared for that part of the world.—C. F. T.

CONCERNING THE HALO OF 46°.

By LOUIS BESSON.

[Paris, France, June 26, 1922.]

In the MONTHLY WEATHER REVIEW of March, 1922, Professor Hastings calls the attention of meteorologists to the halo of 46°, which he believes can be explained by prisms horizontally oriented.

By a singular coincidence the Ellendale phenomenon, whose description is read just following, furnishes a positive answer on this question. If the "bright halo of 46°" observed by Mr. Ling at 11:58 a. m. had been produced by horizontal prisms this luminous arc would have been tangent to the circumzenithal arc instead of being separated from it by a distance of 4° or 5°.

Relative to this may I be permitted to recall that on December 21, 1910,¹ I observed a circumzenithal arc not touching the halo of 46°, and that my associate M. Dutheil observed on February 18, 1912, a short arc 3° above the large halo.²

It is very rare that the nonoriented prisms by adding in this way their effect to that of the others reveal their existence in a manner so characteristic, but there are seen rather frequently halos of 46° that have so manifestly the form of a perfect circle that they could be attributed only to such prisms. I could cite rather numerous examples in our observations at Montsouris.

Professor Hastings objects that the halo of 46° appears only when the sun is not too high. I gave, in 1909, in my memoir on the theory of halos³ figures that indicate in effect that the phenomenon presents a very decided maximum of frequency for a solar elevation of near 20°. What does that prove? Simply that the prisms that produce it have a tendency to orient themselves and that their balancings are of limited amplitude.

It is about the vertical that these balancings appear to be executed. To simplify, let us consider only the highest point of the halo of 46°. It is readily seen that if the sun is at 22° 8' elevation innumerable vertical prisms are effective. If the sun is 10° higher or lower, that is to say at 32° 8' or at 12° 8', it would be necessary that the prisms incline 10° in one direction or in the other. If the sun is at 42° 8' or at 2° 8' balancings of 20° will be necessary.

I shall add that the prisms whose axes oscillate about the horizontal contribute to the production of the halo of 46° when the sun is slightly elevated, but they bring forth especially the lateral parts, while the prisms near the vertical give the upper part.

Most often, but not always, the persistent existence of the maximum of intensity, whether above or at the side, betrays the tendency of the generating crystals toward a definite orientation. This remark is not peculiar to the halo of 46°. It is true also of the halo of 22°, for all

observers know that of it there is seen especially the culminating part or the segments at the elevation of the sun.

It can happen that there is taken for an arc of the halo of 46° a supralateral tangent arc or an arc bitangent to this halo, the coloring being of the same order as that of the halo, from which they are usually difficult to distinguish.

At Montsouris in the first years we sometimes must have made this error, all the more pardonable in that there was not yet certainty as to the real existence of these tangential arcs foreseen by the intuition of Bravais. However, their reality is no longer in doubt, and we have learned to recognize them rather well even when they are very short by their colors, which are more vivid than those of the halo of 46°, and by the accompanying appearance of the tangential arc of 22°. The possibility of a mistake in this regard does not preclude the fact that just as there is a halo of 22° there is also a circular halo of 46° produced by prisms of 90°, whose position is near that of the minimum of deviation in accord with the old explanation by Cavendish.

I find in my notes figures showing under what conditions there appeared 79 halos of 46° observed at Montsouris from 1898 to 1908. It is, perhaps, not without interest to reproduce them here.

Phenomena visible at the same time as the halo of 46° or a little previous.

	Per cent.
Halo of 22°, not brilliant, alone.....	30
Halo of 22°, brilliant, or rather brilliant, alone.....	27
Parhelia.....	13
Tangential arcs of 22°, with parhelia.....	11
Tangential arcs of 22°, without parhelia.....	11
No phenomena.....	5
No definite indications.....	3

When the halo of 46° accompanies a halo of 22° that is brilliant and uniformly so, it may be asked if it is not produced "secondarily" by two successive refractions in prisms of 60°. Its radius would then be 44°. Among our numerous measurements there were three that gave this result, but correctness was not certain.

This is a point to which I take the liberty of directing the attention of observers.

TORNADOES IN WISCONSIN.

By W. P. STEWART, Meteorologist.

[Weather Bureau, Milwaukee, Wis.]

June 15, 1922.—During the evening of June 15, 1922, a destructive thunder squall and tornado swept over parts of four counties in northwestern Wisconsin, causing the loss of eight lives, injuries to about 100 persons, and property damage estimated at \$500,000.

¹ *Annales de l'Observatoire de Montsouris*. Tome XI, p. 47.

² *Loc. cit.* Tome XII, p. 241.

³ *Loc. cit.* Tome X, p. 186.

The weather map, based on the 7 p. m. observations of that date, shows an area of low pressure central over southern Minnesota, the lowest sea-level pressures reported being 29.60 inches, at Minneapolis and Moorhead. To the eastward in the St. Lawrence Valley there was a weak area of high pressure, 30.16 inches at Alpena. At Moorhead, Minneapolis, and Dubuque the wind was light southeast, the current temperatures being 74°, 78°, and 86°, respectively. At Duluth the wind was northeast, 20¹ miles, and the temperature was 50°. It will be seen from the foregoing that conditions were highly favorable for severe local squalls in the region south of Lake Superior.

The tornado originated a few miles north of the town of Roberts, which is slightly southwest of the center of St. Croix County, Wis., and traveled approximately northeast, passing close to the junction of Dunn and Polk Counties, and thence about east-northeast across southern Barron County to the vicinity of Chetek, where it was last reported.

Reports differ as to the exact time of the passage of this storm, but evidently it first was felt, near Roberts, about 7 p. m., and disappeared, near Chetek, about 9 p. m. As the length of the path was approximately 40 miles, the storm as a whole traveled only about 20 miles an hour.

The width of the path of great destruction varied from a few rods to two miles or more. In places along the path, particularly in western Barron County, destruction occurred over an area approximately 15 miles wide. It seems evident that in the wider portions of the storm's path much of the damage was caused by a severe thunder squall, rather than by the tornado proper. The characteristic funnel-shaped tornado cloud was reported from many points, but there were several observers in different localities who failed to see it.

The greatest destruction occurred in northeastern St. Croix County and in southern Barron County, but there was considerable damage in northwestern Dunn County and in southeastern Polk County. The property loss was extremely heavy in Forest Township, St. Croix County, and probably nearly as heavy in Vance Creek Township, Barron County. The greater part of the storm track was through a thinly settled region; otherwise the damage would have been much greater.

Fatalities reported were as follows: One in Polk County, two in St. Croix County, and five in Barron County.

Approximately 100 houses and barns were destroyed, much live stock was killed by wind and lightning, and a wide extent of crops were injured, in many cases the loss being complete. More or less serious damage was reported from the towns of Arland, Chetek, Deer Park, Emerald, Erin, Forest, Hammond, and Vance Creek.

It is believed a conservative estimate of the property loss is \$500,000, probably three-fourths of which represents buildings destroyed, mostly on farms, and the remainder loss of crops, live stock, etc.

Tornado near Antigo.—At 2:30 p. m., June 16, 1922, a tornado passed from southwest to northeast about 2 miles west of Antigo, Langlade County, Wis., destroying about 10 farm buildings, many trees, and some live stock. No fatalities nor personal injuries were reported. The loss of buildings, live stock, etc., is conservatively estimated at \$50,000. The damage to crops was not great. This was a real tornado, although a very brief one, the funnel-shaped cloud being reported by all observers. The width of the path of great destruction was 10 to 20

rods and its length about 1½ miles. Extensive inquiry fails to find any trace of this storm at any other point. The following note is from a report by the postmaster at Bryant, Wis., about 8 miles northeast of Antigo:

The tornadic part of the storm was west of Antigo, although it blew hard here at Bryant without doing any damage of consequence. The tornado looked like it reached up about 1,000 feet or more in the air, with a width of about 10 to 20 rods on the ground decreasing to a narrow strip higher up, and revolving with great velocity.

THUNDERSQUALLS IN WISCONSIN, JUNE 9-10, 1922.

By W. P. STEWART, Meteorologist.

[Weather Bureau, Milwaukee, Wis.]

During the night of June 9, 1922 and during the day following, destructive local thundersqualls swept over many counties in western, southern, and eastern Wisconsin, causing a property loss estimated at over \$500,000. No fatalities were reported and only a few persons injured. Of the property loss probably one half was from the destruction of buildings, mostly on farms, and the remainder from loss of crops, live stock, etc.

Near the town of Eagle Point, Chippewa County, the storm exhibited some of the characteristics of a tornado; at all other points evidently only straight-line winds were involved. No one reported a funnel-shaped cloud. However, in most sections the destruction occurred during the night and had there been such a cloud it would not have been visible.

On the morning of June 9, 1922, an extensive barometric depression covered the Rocky Mountain and plateau regions, with the lowest pressure, 29.56 inches, sea level, at Salt Lake City. The evening map of the same day showed the center of low pressure, 29.42 inches, at Denver, and a development of the low-pressure area eastward across the Lake region to Ontario. At this time, 7 p. m., there was a sharp temperature gradient over Wisconsin, the current readings being: At Madison, 80°; at Dubuque, 82°; at Milwaukee and Minneapolis, 70°; at Marquette, 50°, and at Duluth, 44°. On the morning of June 10 there was an elongated area of low pressure extending from Arizona to Ontario, with the lowest pressure, 29.54 inches, at Omaha. By the morning of the 11th the area of low pressure had passed into the St. Lawrence Valley and a moderate high-pressure area had overspread the entire West.

Destructive winds were first reported about 11 p. m., June 9, in Dunn County, in northwestern Wisconsin. From that point they spread to the east and southeast and did not subside in some eastern counties until midnight the 10th. Most of the damage occurred between midnight of the 9th and daybreak of the 10th. However, the destruction in Sauk County occurred about 10 a. m.; that in Dane County about 11 a. m., that in Waupaca County not until 3 p. m.

The property loss in Chippewa and Dunn Counties was extremely heavy, the estimate of one reporter being \$300,000 for Chippewa County alone. The damage was nearly as great in Jackson, Sauk, Green Lake, and Fond du Lac Counties, and there was serious loss in Eau Claire, Dane, Jefferson, Waupaca, Winnebago, and Calumet Counties. Following is a description of the storm at Eagle Point, Chippewa County, as given by Mr. C. L. Richardson of Chippewa Falls:

The storm apparently had none of the features of the western tornado, but rather resembled the thunderstorm, marked only by unusual intensity of the wind. It advanced broadside across the country,

¹ Doubtless due to the local topography at the Weather Bureau station.—Edron.